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METEOROLOGICAL DATA BASE FOR THE MUSKOKA/HALIBURTON AREA

DATA REPORT DR 86/5

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M48
1986

Ministry of the Environment

J. BISHOP, Director
Water Resources Branch

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METEOROLOGICAL DATA BASE FOR THE MUSKOKA/HALIBURTON AREA

B.A.Locke and E.deGrosbois

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PREFACE

The Data Report Series is intended as a readily available source of basic data collected for lakes and watersheds in the Muskoka/Haliburton area of Ontario. These data were collected as part of the Lakeshore Capacity Study and/or the Acid Precipitation in Ontario Study.

The limnological portion of the Lakeshore Capacity Study (1975-81) was initiated to investigate the relationships between lakeshore development and lake trophic status in low ionic strength Precambrian lakes. The Acid Precipitation in Ontario Study (1979-present) was initiated, in part, to investigate the effects of the deposition of strong acids on aquatic and terrestrial ecosystems in Ontario. The primary findings of these studies have been and will continue to be published as reviewed papers and technical reports.

ABSTRACT

This report outlines the scope, applications and procedures for utilizing a meteorological data base available for the Muskoka/Haliburton area. The data are currently stored on the Dorset Research Centre's Hewlett-Packard 9845 computer system.

Locke, B.A. and E. de Grosbois. 1986. Meteorological Data Base for the Muskoka/Haliburton Area. Ont. Min. Environ. Data Report DR 86/5.

Table of Contents

		Page
1.	Introduction	1
2.	Data Base Background Information	1
	2.1 Sources of Meteorological Data	1
	2.2 Data Base Requirements and Specifications	3
	2.2.1 Data Base Architecture	3
	2.2.2 Data Set Format	4
	2.2.3 Data Validity	4
	2.2.4 Interpretation	4
	2.2.5 Up-dating Data	5
	2.3 Currently Available Meteorological Data	5
3.	Applications of the Data Base	17
4.	Collection Methodology	18
	4.1 AES - Environment Canada	18
	4.2 Dorset Research Centre (DRC) Precipitation and Hydrometeorological Network	19
	4.3 Ministry of the Environment - Air Resources Branch (ARB)	29
	4.4 Other Source Agencies	29
5.	References	30
6.	Appendices	
	6.1 Source Agency Contact Information	31
	6.2 Hewlett-Packard Regression Format	32
	6.3 'METEOR'	33
	6.4 'EVAPR8'	38

1. Introduction

Meteorological data plays a key role in the determination of chemical and hydrological budgets of lakes and catchments. Because of this, a meteorological data base has been generated for the Muskoka/Haliburton area (station locations are shown in Figure 1). This data base is comprised of daily and hourly records for a variety of weather-related information collected at a total of 51 stations. The records start on January 1, 1976 (although many stations have been in operation longer) and are current to mid 1985. This data base will be kept up to date by routine procedures outlined in this report. Applications for these data, and procedures for utilizing this data base are described in detail in this report.

2. Data Base Background Information

2.1 Sources of Meteorological Data

The sources of the available meteorological data for Muskoka/ Haliburton include the following:

Environment Canada:

AES - Canadian Climate Centre
Atmospheric Environment Service

CCIW - Canada Centre for Inland Waters
National Water Research Institute,

Ontario Ministry of the Environment:

ARB - Air Resources Branch

DRC - Dorset Research Centre, Limnology Unit, Water Resources Branch

Ontario Ministry of Natural Resources:

MNR - Ministry of Natural Resources

More detailed information on each source agency is given in Appendix 6.1.

The data are requested on computer medium and in documentation form. All information is subsequently re-coded so that variable type, quality control and station ID codes are consistent, then re-formatted and stored on the Dorset Research Centre's

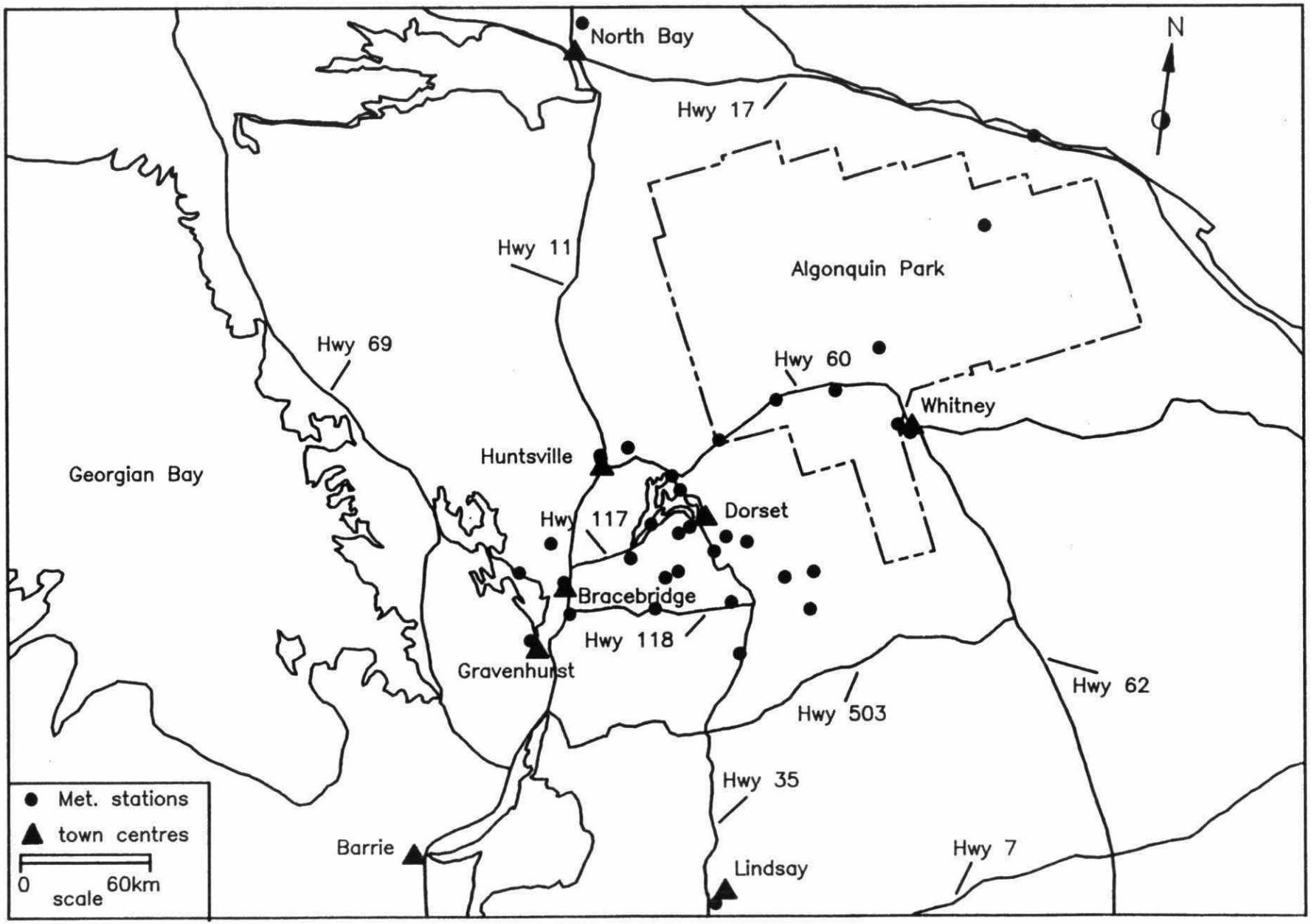


Figure 1. Map illustrating Data Base Meteorological Stations in South-central Ontario

Hewlett-Packard 9845-B computer system. Eventually, the data will be accessed by the site's Hewlett-Packard 1000 System. Generally data are available 6 months after observation, but delays of up to 18 months may be encountered. More current information can sometimes be obtained, but it may not have been subjected to the same quality assurance guidelines.

2.2 Data Base Requirements and Specifications

2.2.1 Data Base Architecture

Data for each meteorological parameter available for each site are stored as separate files on 8" floppy disks and on magnetic tape. Each data set is indexed with a consistent set of codes for sites and variables (these codes are discussed in section 2.3).

The meteorologic data (selected by station and data type) are read from magnetic tapes and stored in regression format on the Hewlett-Packard computer system. These data, however, are not received in a consistent or standard format and must be re-formatted individually to meet our storage design. Other data, not available on computer records, is entered by hand into the data base directly. Should turn-around time for acquiring selected data types on computer medium prove to be too long, this method may form a viable alternative. The entire data base contents are also listed (as stored) by data type and by station and are available as a library reference from Barbara Locke.

Computer programs have been developed to collate and store this data base. Programs are also available to access and utilize meteorological data from the existing data base. These are useful in calculations involving lake evaporation, lake heat budget modelling, and, in estimating regional weather parameters.

2.2.2 Data Set Format - Each data set is stored as a two-dimensional flat file (observations by variables) and is station and data-type specific. The record format for each data set is the standard defined by the Hewlett-Packard Regression Analysis package (Appendix 6.2). The units of measurement are all standardized for each data type. Each file contains three variables: a date (yymmdd.hhmm; where yy is the year, mm is the month, dd is the day, hh is the hour, and mm is minutes), a corresponding meteorologic measurement and a quality control (QC) flag for that measurement. These QC flags describe any irregularities in the data.

2.2.3 Data Validity - Data from all sources are subject to quality assurance and control. This requires that data be checked and recoded or transformed (if necessary) before entry to computer records. No further editing of the data base should be necessary. Data flags employed by source agencies for quality control purposes have been recoded to a consistent set of QC codes in the data base. Additional QC codes can be added as required.

2.2.4 Interpretation - Most meteorological data are collected using highly standardized methods. However, even routine observations are subject to changing conditions and interpretation due to data transfer from field records to the data base. Any secondary information that may have bearing upon the data should be recorded and form part of the data base. This information is archived as part of the meteorological data base and may include the sourcing agency, source agency coding conventions (both for data items and data quality), original tape receipts and printer documentation, site descriptions and locations (UTM grid co-ordinates) and meteorological gauges in use at the site. Missing data to the actual data records are not estimated or interpolated because any methodology used would be interpretive and the integrity of the source data would be lost. Use of programs to estimate

area weather parameters which incorporate any missing values must be well documented. Estimated, interpolated and calculated values are indicated by an appropriate and consistent set of quality control codes. Appendix 6.3 details the quality control codes provided by an estimation program.

2.2.5 Up-dating Data - This data base will be kept current and up-dated periodically. Storage space for 51 stations and 35 meteorologic parameters has been set up, although not all data is presently stored as part of the data base. New data will be re-formatted and recorded as necessary and added to the present storage format. Data will be updated by keyboard entry or by merging with new files on magnetic tapes. Arrangements are made with the agencies that supply meteorological data to provide the Dorset Research Centre with periodic updates.

2.3 Available Data

Meteorological data collection sites and meteorological variables are listed in Tables 1, 2 and 3. The data base currently has data stored from 15 of the 51 stations for 19 of the 35 different meteorologic parameters. Continual additions to the system will provide a more complete record. Each data set contains information pertaining to temporal series or temporal events of that variable at that site.

Tables 1 and 2 describe the 51 meteorological monitoring sites near the Muskoka/Haliburton area. Site descriptions are reduced to a 3-digit station abbreviation code shown in column 2. Similar nominal sites are differentiated on the basis of their operating agency, differences in gauging equipment at the site (see Table 2), differences in UTM co-ordinates (ie. the station may have been moved), and differences in operating dates. Column 4 (Magnetic tape key) in Table 2 indicates which stations are stored as part of the data base. Source agency codes are listed in Appendix 6.1. Gauge type key fields are listed in Table 3.

Table 4 summarizes the meteorological data types. Data type descriptions are reduced to a 2-digit variable code, and are further classified into sub-types by: A = Actual observations, M = mean value for the time period, T = total for the time period, U = the upper limit, and L = the lower limit for the time period indicated. An S and V are used to indicate scalar or vector averages, respectively, in measuring wind speed. Availability of data for a particular variable type is indicated by the column entry under the sub-type letter, (eg. 01U - maximum daily air temperature has an entry under L in row 01). The number indicates the floppy disk number where these data sets can be found. If this value is "000" then no data is available. The contents of each disk (ie. which sites are available for each variable type) are listed in Table 5. The data set names on the computer are composites of the 3-digit site code and the 3-digit data type description code.

Each data set contains a quality control flag variable (variable #3) which describes any irregularities in the data. Table 6 summarizes the flags used with accompanying descriptions. The data base stores the numeric code along with each meteorologic measurement in the computer file record.

Table 1. List of meteorological stations available for reference to the data base, including source agency, 'UTM' location coordinates and operation dates. This information along with the data in Table 3 is stored on HP 9845B disk #231 as 'M-SITE', accessible to data base computer programs.

Site Description	Stn Abbrev	Source Agency	Location Coordinates UTMe	UTMn	Operation Dates Start	End*
ALGONQUIN AIR/MEW L.	AE1	DRC	0694600	5049650	780509	800520
ALGONQUIN EAST AFAU	AE2	DRC	0713950	5045950	800602	840930
ALGONQUIN EAST Gate	AE3	AES	0713950	5045950	800902	999999
ALGONQUIN WEST Gate	AW1	MNR	0670450	5034100	820101	999999
BEATRICE 1 -	BE1	AES	0627000	4999350	760101	790228
BEATRICE 2 -	BE2	AES	0625850	4999000	790430	999999
BRACEBRIDGE 1	BR1	AES	0633200	4988350	830730	999999
BRACEBRIDGE 2 (formerly MB1)	BR2	AES	0632600	4989450	840801	999999
CARNARVON (Reid home)	CA1	DRC	0677700	4989245	760816	790124
CLEAR LK. (island stn)	CL1	DRC	0679650	5005300	780829	790704
CROSSON LK. (raft)	CN1	DRC	0654600	4993900	800508	821116
DORSET (met site) -	DO1	AES	0662400	5009650	770901	999999
DORSET (PT1 Paint Lk.)	DO2	DRC	0662700	5009425	761109	791130
DORSET (PT1 micro site)	DO3	DRC	0662375	5009675	791130	821108
DORSET (PT1 met site)	DO4	DRC	0662350	5009850	821117	999999
DWIGHT -	DW1	AES	0656400	5021500	730130	999999
EAGLE LK. (hydro line)	EA1	DRC	0693950	4999050	760817	800502
FROST CENTRE (L.M.)	FR1	MNR	0669250	5002800	999999	999999
GULLFEATHER (raft)	GF1	DRC	0655850	4995300	760730	781108
GRAVENHURST	GR1	AES	0626250	4974825	800601	999999
HALIBURTON -	HA1	AES	0693000	4987500	760101	999999
HARP LAKE (raft)	HP1	DRC	0646050	5026700	999999	999999
HARP LK 3A watershed	HP2	DRC	0645500	5026400	821116	840502
HARP LK 4A watershed	HP3	DRC	0645500	5026875	840107	999999
HARP LK 4 terrest.	HP4	UoT	0645250	5026600	820824	999999
HARP LK 7->3A weir	HP5	AES	0646400	5027000	999999	999999
HUNTSVILLE WPCT -	HU1	AES	0640500	5021100	760101	999999
HENEY LK west field	HY1	DRC	0649325	4999000	821116	841030
HENEY LK east field	HY2	DRC	0649850	4999000	840110	999999
LINDSAY-SSFC Frost Campus -	LI1	AES	0681700	4913300	760101	999999

Table 1 (cont'd)

Site Description	Stn Abbrev	Source Agency	Location Coordinates UTMe	UTMn	Operation dates Start	End*
MILFORD BAY now BR2	MB1	AES	0619400	4995125	760101	840701
MINDEN Jan 1 1956 ->	- MI1	AES	0679900	4978350	760101	999999
MUSKOKA AIRPORT FSS	- MU1	AES	0633450	4980700	760101	999999
NORTH BAY AIRPORT	- NB1	AES	0620500	5133800	760101	999999
NITHGROVE	NI1	ARB	0651600	5006800	810506	999999
OPEONGO LK Harkness Lab	- OP1	AES	0705750	5056600	760501	841031
OXTONGUE R. MNR Eng	OX1	MNR	0657550	5019425	830901	999999
PLASTIC LK raft PCPR	PC1	DRC	0671000	5005000	800502	821116
PLASTIC LK gravel pit	PC2	DRC	0669900	5003950	821118	841030
PLASTIC LK north	PC3	DRC	0671050	5005250	840117	999999
PLASTIC LK terrest.	PC4	UoT	0670600	5005400	820808	999999
RED CHALK Lk raft	RC1	DRC	0661000	5005850	760803	781102
SMOKE LK air base	SM1	MNR	0679850	5045500	830801	999999
STONECLIFFE	- ST1	MNR	0661400	5005900	760501	830831
TRAVERSE LK (Alg. Pk)	TR1	MNR	0728625	5092450	999999	999999
VANKOUGHNET	- VA1	AES	0658125	4988050	760801	781019
VANKOUGHNET (Clear Lk)	VA2	DRC	0658125	4988050	760505	800508
WEST GUILFORD	- WG1	AES	0681900	4996500	760101	999999
WHITNEY	- WH1	MNR	0713950	5045950	760401	830831
WILLIAMSPORT	WL1	AES	0644100	5028000	820101	999999

* 999999 denotes station currently operating

- indicates stations for which we have accessed data by magnetic tape

Table 2. List of meteorological stations with the magnetic tape key column indicating those sites with meteorological data presently stored in the data base. Gauge (or instrumentation) information is listed for each station.

Site Description	Stn Abbrev	Source Agency	Magnetic tape* Key 1234567890	Gauge Code Key** 1111111112 1234567890123456789
ALGONQUIN AIR/MEW L.	AE1	DRC	.....	11....11.....
ALGONQUIN East AFAU	AE2	DRC	.....	11....11.....
ALGONQUIN East Gate	AE3	AES	.....	11.....
ALGONQUIN West Gate	AW1	MNR	.....	...1.....
BEATRICE 1	BE1	AES	1.....	1...1...1.....
BEATRICE 2	BE2	AES	1.1.....	1...1...1.....
BRACEBRIDGE 1	BR1	AES	.....	1.....1.1.....
BRACEBRIDGE 2 (formerly MB1)	BR2	AES	.....	1...1...1.....
CARNARVON (Reid home)	CA1	DRC	.....	11....11.....
CLEAR LK. (island stn)	CL1	DRC	.....	11....1.....
CROSSON LK. (raft)	CN1	DRC	.....	11....1.....
DORSET (met site)	DO1	AES	111.....	11111.111.111.....
DORSET (PT1 Paint Lk.)	DO2	DRC	.....	11....11.....
DORSET (PT1 micro site)	DO3	DRC	.....	11....11.....
DORSET (PT1 met site)	DO4	DRC	.....	11....1.....
DWIGHT	DW1	AES	1.1.....	1...1...1.....
EAGLE LK. (hydro line)	EA1	DRC	.....	11....11.....
FROST CENTRE (L.M.)	FR1	MNR	.....	.....1....1.....
GULLFEATHER (raft)	GF1	DRC	.....	1.....1.....
GRAVENHURST	GR1	AES	.....	1...1...1.....
HALIBURTON	HA1	AES	1.1.....	1...1...1.....
HARP LAKE (raft)	HP1	DRC	.....	11....11.....
HARP LK 3A watershed	HP2	DRC	.....	11....1.....1.....
HARP LK 4A watershed	HP3	DRC	.....	11.1..1.....
HARP LK 4 terrest.	HP4	UoT	.....	1.1.....111...
HARP LK 7->3A weir	HP5	AES	.....	.....1.....
HUNTSVILLE WPCT	HU1	AES	1.1.....	1...1...1.....
HENEY LK west field	HY1	DRC	.....	11....1.....

Table 2 (cont'd)

Site Description	Stn Abbrev	Source Agency	Magnetic tape* key 1234567890	Gauge Code Key** 11111111112 12345678901234567890
HENEY LK east field	HY2	DRC	....	...1..1..............
LINDSAY-SSFC Frost Campus	LI1	AES	1.1.......	1.1.1...1111........
MILFORD BAY now BR2	MB1	AES	....	1...1...1...........
MINDEN Jan 1 1956 ->	MI1	AES	.11.......	1...1...1...........
MUSKOKA AIRPORT FSS	MU1	AES	111.......	11......1.11........
NORTH BAY AIRPORT	NB1	AES	111.......	111.....1111........
NITHGROVE	NI1	ARB	....	11..................
OPEONGO LK Harkness Lab	OP1	AES	.11.......	1.......1..1........
OXTONGUE R. MNR Eng	OX1	MNR	....	...1................
PLASTIC LK raft PCPR	PC1	DRC	....	11....1.............
PLASTIC LK gravel pit	PC2	DRC	....	11....1.............
PLASTIC LK north	PC3	DRC	....	...1..1.....1.......
PLASTIC LK terrest.	PC4	UoT	....	1.1...........111...
RED CHALK LK raft	RC1	DRC	....	11....1.............
SMOKE LK AIR BASE	SM1	MNR	....	...1................
STONECLIFFE	ST1	MNR	11........	1.......1...........
TRAVERSE LK (Alg. Pk)	TR1	MNR	....	1...1...1...........
VANKOUGHNET	VA1	AES	1.........	1.1.1...1...........
VANKOUGHNET (Clear Lk)	VA2	DRC	....	11....1.............
WEST GUILFORD	WG1	AES	1.1.......	1.1.1...1...........
WHITNEY	WH1	MNR	11........	..1.....1...........
WILLIAMSPORT	WL1	AES	....	...1................

*3 magnetic tapes with meteorologic data for 15 sites stored on the data base. A "1" in any of the first 3 fields indicates that data for that site is available for reference. The 3 magnetic tapes in key fields 1-3 are: DRST09, DRST10 and C21336 respectively

**The 20 field gauge code key is summarized in Table 3.

Table 3. Descriptions of the codes used for denoting the types of gauges present at each meteorological station

Key Field* Indicator	Sample Information System Code #	Gauge Description
1	0	SRG - Standard Rain Gauge
2	1	Nipher Gauge
3	2	Tipping Bucket Rain Gauge
4	3	Belfort Rain Gauge
5	4	Snow Ruler
6	9	Volume Calc. from Precipitation Collector
7	62	2500 cm^2 square Bulk Precipitation Collector
8	61	Cramer Wet-only Precipitation Collector
9	5	Max-min (daily) Thermometer
10	6	Evaporation
11	7	Wind (speed/direction)
12	8	hrs. sunshine
13	10	snow survey
14	11	Fischer-Porter - logger or chart
15	-	Stemflow }
16	-	Throughfall collectors } terrestrial monitors
17	-	Lysimeters }
18	-	Dew Pt (wet/dry thermometer)
19	-	Radiation (global and photosynthetically available)
20	-	available

*Key Field Indicator:
Denotes where in the 20 space character string 'Gauge Code' of Table 2 the number 1 will appear if that gauge is present at the meteorological station.

Table 4. Meteorologic data types currently available in the data base. The number under each column denotes the computer disk number where that data type is stored in station specific files, (000 indicates that no data is stored on computer disk).

Variable Code		Variable Description	Actual (A)	Mean (M)	Total (T)	Upper (U)	Lower (L)	Scalar (S)	Vector (V)
01	DLY	AIR TEMP. (deg C)	000	272	000	279	278	000	000
02	DLY	WATER TEMP. (deg C)	000	271	000	000	000	000	000
05	DLY	DEW POINT TEMP. (deg C)	000	271	000	000	000	000	000
10	DLY	PRECIPITATION (mm H20)	000	000	273	000	000	000	000
11	DLY	PRECIPITATION Rain (mm (H20)	000	000	270	000	000	000	000
12	DLY	PRECIPITATION snow (mm H20)	000	000	277	000	000	000	000
13	DLY	PRECIPITATION snow (depth)	000	000	277	000	000	000	000
15	DLY	BRIGHT SUNSHINE (h)	000	000	271	000	000	000	000
16	DLY	SOLAR RADIATION (1ys)	000	000	271	000	000	000	000
17	DLY	PHOTOSYNTHETICALLY AVAILABLE RADIATION (1ys)	000	000	271	000	000	000	000
18	DLY	MAXIMUM SUNSHINE (h)	000	000	000	271	000	000	000
20	DLY	RELATIVE HUMIDITY (%)	000	271	000	000	000	000	000
21		RELATIVE HUMIDITY at 1300h (%)	000	000	000	000	000	000	000
25	DLY	VAPOUR PRESSURE (mb)	000	271	000	000	000	000	000
31	DLY	PAN EVAPORATION (mm)	000	000	271	000	000	000	000
32	DLY	LAKE EVAPORATION (mm)	000	000	271	000	000	000	000
35	DLY	WIND SPEED (km/h)	000	000	000	000	000	271	000
36	DLY	WIND DIRECTION (dg)	000	000	000	000	000	000	271
37	DLY	WIND MILEAGE (km)	000	000	000	000	000	000	000
40	DLY	MEAN hourly SO_2	276	276	000	000	000	000	000
45	DLY	MEAN hourly NO_X	276	276	000	000	000	000	000
50	HLY	AIR TEMP. (deg C)	000	000	000	000	000	000	000
55	HLY	DEW POINT (deg C)	000	000	000	000	000	000	000
60	HLY	PRECIPITATION (mm H20)	000	000	000	000	000	000	000
61	HLY	PRECIPITATION rain (mm H20)	000	000	000	000	000	000	000
62	HLY	PRECIPITATION snow (mm H20)	000	000	000	000	000	000	000
65	HLY	BRIGHT SUNSHINE (h)	000	000	000	000	000	000	000
66	HLY	SOLAR RADIATION (1ys)	000	000	000	000	000	000	000
67	HLY	PHOTOSYNTHETICALLY AVAILABLE RADIATION (1ys)	000	000	000	000	000	000	000
70	HLY	RELATIVE HUMIDITY (%)	000	000	000	000	000	000	000
75	HLY	VAPOUR PRESSURE (mb)	000	000	000	000	000	000	000
81	HLY	PAN EVAPORATION (mm)	000	000	000	000	000	000	000
82	HLY	LAKE EVAPORATION (mm)	000	000	000	000	000	000	000
85	HLY	WIND SPEED (km/h)	000	000	000	000	000	000	000
86	HLY	WIND DIRECTION (deg)	000	000	000	000	000	000	000

NOTE: This information is stored on HP 9845B disk #231 as 'M-VARS' (a program accessed by other data base computer programs).

Table 5. Disk catalogue (HP 9845B storage) of meteorologic station and data type specific files. The file names on the data disks (270-279) are composites where the first three digits are the station abbreviation, the next two represent the meteorologic parameter and the last letter denotes the type of data.

File Name	Disk #	Data description
M-OLD	231	Program disk
KEYS	"	"
U-OLD	"	"
METAP3	"	"
VARLST	"	"
UTMLST	"	"
V-OLD	"	"
METAP4	"	"
METAP5	"	"
ADDMET	"	"
TCCIW3	"	"
EVAPR8	"	"
ADDM2	"	"
EVAP1D	"	"
SRregf	"	"
M-SITE	"	"
CORREC	"	"
RDTAPE	"	"
LIST	"	"
METEOR	"	"
M-VARS	"	"
AREA	"	"
MSITES	"	"
MVARS	"	"
BE111T	270	Total daily precipitation (as
BE211T	"	rain, element code 11T)
DO111T	"	"
DW111T	"	"
HA111T	"	"
HU111T	"	"
L1111T	"	"
MU111T	"	"
NB111T	"	"
VA211T	"	"
WG111T	"	"
OP111T	"	"
MI111T	"	"
ST111T	"	"
WH111T	"	"
MU120M	271	Element codes for these files can
LI115T	"	be found in Table 2
NB115T	"	"
NB120T	"	"
DO116T	"	"
MU105M	"	"

Table 5 (cont'd)

File Name	Disk #	Data Description
NB105M	271	Element codes for these files can be found in Table 2
LI131T	"	"
LI135S	"	"
LI102M	"	"
LI132T	"	"
DRC18U	"	"
DO120M	"	"
DO125M	"	"
DO135S	"	"
DO136V	"	"
DO117T	"	"
BE101M	272	Mean daily air temperature (element code 01M)
BE201M	"	
DO101M	"	"
DW101M	"	"
HA101M	"	"
HU101M	"	"
LI101M	"	"
MU101M	"	"
NB101M	"	"
VA101M	"	"
WG101M	"	"
OP101M	"	"
MI101M	"	"
AIRTLF	"	"
BE110T	273	Total daily precipitation (as rain and/or snow, element code 10T)
BE210T	"	
DO110T	"	
DW110T	"	"
HA110T	"	"
HU110T	"	"
LI110T	"	"
MU110T	"	"
NB110T	"	"
VA110T	"	"
WG110T	"	"
OP110T	"	"
MI110T	"	"
ARB1	276	SO_3/NO_x chemistry
ARB01	"	"
DO140M	"	"
BA140M	"	"
DO145M	"	"

Table 5 (cont'd)

File name	Disk #	Data Description
BE112T	277	Total daily precipitation (as snow, element code 12T) and on-ground snow depth (element code 13T)
BE212T	"	
DO112T	"	
DW112T	"	"
HA112T	"	"
HU112T	"	"
LI112T	"	"
MU112T	"	"
NB112T	"	"
VA112T	"	"
WG112T	"	"
OP112T	"	"
MI112T	"	"
NB113T	"	"
MU113T	"	"
BE101L	278	Daily minimum air temperature (element code 01L)
BE201L	"	
DO101L	"	"
DW101L	"	"
HA101L	"	"
HU101L	"	"
LI101L	"	"
MU101L	"	"
NB101L	"	"
VA101L	"	"
WG101L	"	"
OP101L	"	"
MI101L	"	"
ST101L	"	"
WH101L	"	"
BE101U	279	Daily maximum air temperature (element code 01U)
BE201U	"	
DO101U	"	"
DW101U	"	"
HA101U	"	"
HU101U	"	"
LI101U	"	"
MU101U	"	"
NB101U	"	"
VA101U	"	"
WG101U	"	"
OP101U	"	"
MI101U	"	"
ST101U	"	"
WH101U	"	"

Table 6. Table of flags (Alpha code - AES assigned , Numeric code - DRC assigned)

Flag Numeric*	Alpha	Definition
0	-	No irregularities exist
1	A	Accumulated amount
2	B	More than one occurrence and estimated
3	C	Precipitation occurred, amount uncertain; value is 0
4	D	derived
5	E	estimated
6	F	accumulated and estimated
7	G	uncorrected
8	H	freezing
9	I	unadjusted
10	J	freezing and unadjusted
11	K	first occurrence when precip. may or may not have occurred; value is 0
12	L	precip. may or may not have occurred; value is 0
13	M	missing
14	N	not assigned
15	O	"
16	P	"
17	Q	"
18	R	"
19	S	more than one occurrence
20	T	trace, value is set to 0.0
21	U	valid data, unknown snow
22	V	" , no snow cover
23	W	" , with snow cover
24	X	estimated, unknown snow
25	Y	" , no snow cover
26	Z	" , with snow cover

* this numeric code appears in variable 3 ('QC CODE') of all stored data sets.

3. Applications of the Meteorological Data Base

In addition to providing an accurate and complete catalogue of historical weather-related information for Dorset and area stations these data can be used for budget and modelling calculations. The data base forms the basis for estimating meteorological data on a site-specific or regional basis. The estimates can, in turn, provide the basis for calculating less reliably measured parameters such as evaporation and evapo-transpiration. It can also be used in quality assurance of stream hydrology data by viewing concurrent plots of air temperature, precipitation and hydrology. Both precipitation and evaporation estimates are also used in calculating annual hydrological budgets.

There are several programs available to facilitate the retrieval and manipulation of meteorological data. Principal of these is a program called 'METEOR'. 'METEOR' was developed to estimate and organize specific meteorological data into new files; either by station or by variable. Data can also be estimated from neighbouring sites by several methods. This eliminates any missing values from a created data set and provides comparative data for an area. A complete explanation of 'METEOR' is given in Appendix 6.3. Another program called 'EVAPR8', was designed to estimate evaporation over a lake surface area. This program is described in Appendix 6.4.

4. Collection Methodology

4.1 AES - Environment Canada

The Atmospheric Environment Service (Canadian Climate Centre) maintains a network of weather stations in all parts of the country. Most of these stations are operated on a volunteer basis by private individuals. These stations provide a daily record of precipitation and temperature. The data are published by AES in the form of daily, monthly and annual summaries. Table 2 indicates the AES stations with gauge code types, and Table 3 gives a brief description of these gauges. The following list itemizes the specifics of the instruments used by the network (Atmos. Env. Serv., 1977):

- Stevenson Screen set up at standard height and dimensions, containing the maximum and minumum thermometers.
- Maximum thermometer, mercury filled, in a protective aluminum sheath.
- Minimum thermometer, alcohol filled, in a protective aluminum sheath.
- Rain Gauge Type B (large capacity - 250 mm rainfall) or the Standard Rain Gauge (Copper - 110 to 130 mm rainfall).
- Standard Snow Ruler (1m long, marked in centimetres and fifths, Trace or 'T' is less than 0.2 cm), and snow board.
- Tipping Bucket Rain Gauge - MSC pattern (TBRG) measures and records the rate of rainfall (recorded as ink steps on a chart where 1 step = 0.2 mm rainfall, the recorder is daily or weekly and is a modified anemograph).
- Nipher shielded snow gauge for daily estimation of precipitation as snow in mm.
- Fischer-Porter Recording Precipitation Gauge, automatic, weighs the precipitation collected every 15 min. and records the information on a tape, Series 35B1558 and 35B1559, Fischer and Porter Co., Penn., U.S.A.
- Campbell-Stokes sunshine recorder to record total number of hours of sunshine per day.
- Evaporation Pan system, Class A.

. Wind system -45B Anemometer with 02A direction and speed detector.
. Ceiling Balloon equipment (Helium Inclined Alden) to estimate cloud height above ground.
. Dew point temperature measured with dry/wet bulb thermometers.

4.2 Ministry of the Environment, Dorset Research Centre (DRC) Precipitation and Hydrometeorological Network

As part of the Acidic Precipitation in Ontario Study (APIOS), the Ministry of the Environment (Limnology Unit) in Dorset is involved in the collection of hydrometeorological data to correlate with precipitation. These chemistry monitoring data, with the results of other studies, are used to quantify the relationship between the deposition of strong acids and other contaminants, and the chemical fluxes in watersheds and lakes.

The following is a summary of the technical field methods used for the collection and monitoring of the Limnology Unit's precipitation and hydrometeorological network.

a) The locations of the DRC sites (both previously and currently monitored) are included in Table 1 and are also described in Table 7. The four sites currently operating (DO4, PC3, HP3 and HY2) are maintained conforming to all prescribed quality standards (ie. sampling of precipitation events, cleanliness of the equipment, and attention to the site maintenance).

b) Equipment Description and Operational Procedures:

A typical precipitation site is illustrated in Figure 2, sections A1-A4. Section A1 illustrates a 2500 cm^2 square Bulk Sampler set upon a stand, such that the top was maintained at 1.52m above ground level.

Table 7: Dorset Research Centre precipitation and hydrometeorological network stations. Data are collected every 10 min, hourly, daily and for precipitation event periods, depending on the meteorological parameter

Site Code		Description
Data Base	DRC	
DO4	PT1P	Dorset meteorological site
	PT2	Dorset meteorological site (duplicate collector)
PC2	PCP1	Plastic Lake (Dawson pond gravel pit)
HP2	HPP	Harp Lake (Harp 3a weir site)
HY1	HYP	Heney Lake (Heney homestead - west field)
AE2	ANB	Algonquin (East gate - monitored by A.F.A.U. presently)
PC3	PCP2	Plastic 1 watershed (former terrestrial sites)
HP3	HPP2	Harp 4 watershed (north on the Harp Lake Road, 5 km from Hwy 60)
HY2	HYP2	Heney (Heney homestead - east field)

i) Bulk Collector

Equipment required for operation of the bulk collector during the summer frost-free period (May 1-October 31, approximately) includes:

1) Narrow-mouth teflon-coated funnel.
2) Glass container (switched to 18 L plastic jugs in the summer of 1984) with a tygon tubing connection to the funnel. This container should not be cleaned with Extran 300 as it is impossible to adequately rinse the inside of the container.
3) Standard Rain Gauge (SRG) mounted vertically on a stand at a constant height of 1.67 m above ground level.
4) 4 L graduated cylinder to measure sample volume and 76 µm mesh to filter samples.
5) Nitex screening with a mesh size of 1 mm. This screening should be precut into 10 cm squares and distilled water washed. Transportation to the field should be in a 1 (one) L bottle filled with distilled water.
6) Disposable plastic gloves (one pair per site).
7) Plastic squirt bottle for distilled water (1 L in size).

For sample collection during the winter (November 1-April 30) period, the following equipment is required:

1) Wide-mouth teflon-coated funnel.
2) Nalgene containers (approx. 11 L) with no connection to the funnel (minimum evaporation and freezing preclude connection). This container may be washed with Extran 300.
3) Nipher gauge set in a nipher shield mounted on a stand 1.7 m high.

At the start of each collection period, a set of site specific containers was marked with the appropriate station identification code. These containers were rinsed three or more times with distilled water. After the final rinse, a quantity of distilled water was left in each container for a period of 24 hours. From this, a complete set of chemical parameters was

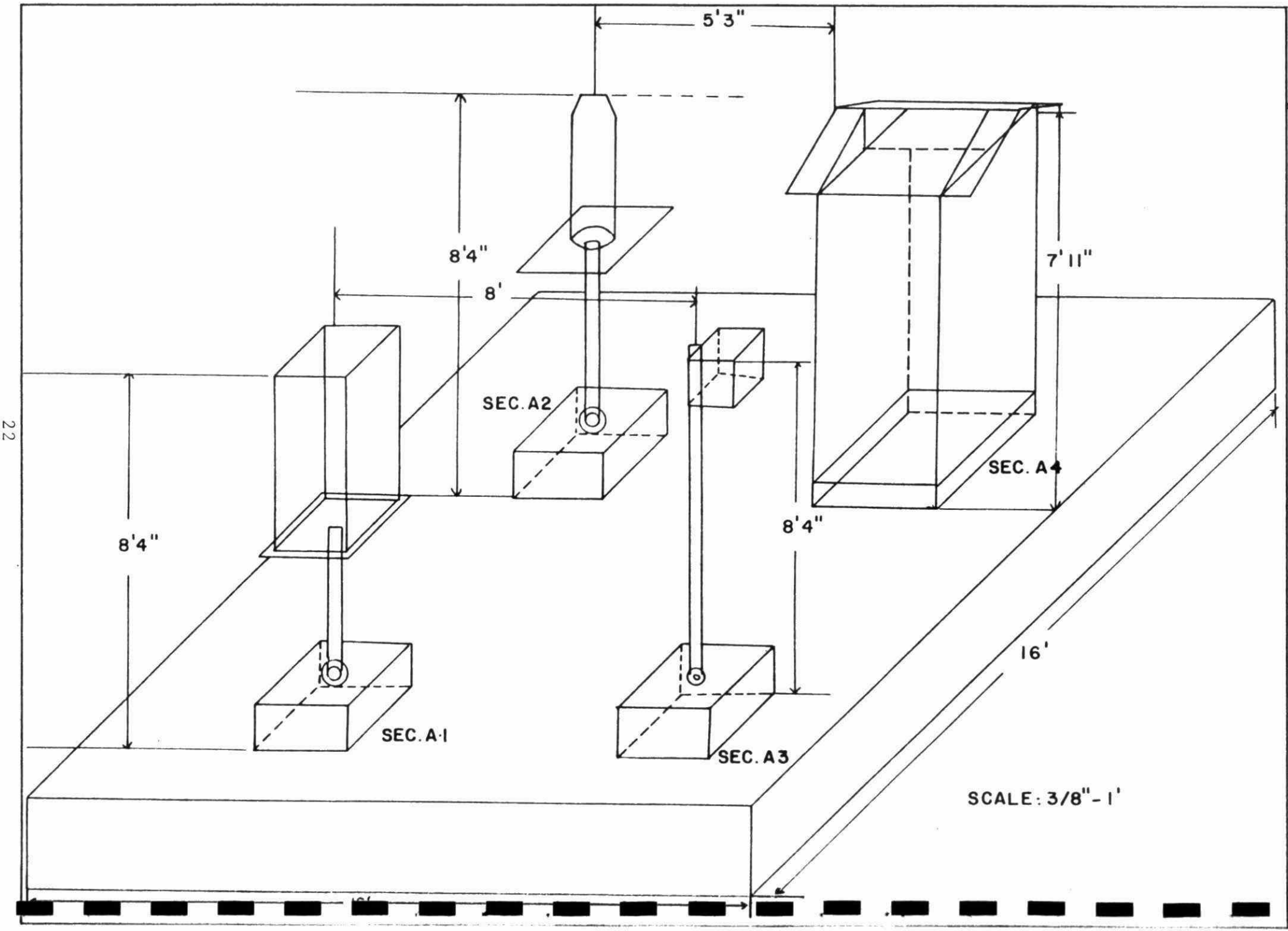


Figure 2. Precipitation Site Instrument Placement

submitted to the appropriate laboratory. As these bottles were interchanged with each other on a continuous basis, an ongoing chemical check for conductivity was run on a distilled water sample left in the container for a period of 24 hours on a monthly basis. Deviations from the background levels of the distilled water were reported.

After a precipitation event (minimum depth 10 mm to allow for adequate rinsing and completely filled sample bottles), both the depth gauge (SRG or nipher) were checked. The SRG was recorded, then emptied and replaced on the stand. The Nipher gauge, if thawed, was measured in a glass graduated cylinder designed to convert snowfall to a rain depth in mm. If the Nipher gauge contents were frozen, a new cylinder replaced it on the stand, ensuring that the replacement cylinder was level with the Nipher shield orifice. The original cylinder was brought back to the lab to be melted and measured. If the Nipher was capped over, the total collection was discarded, and the depth of precipitation (ht) was calculated from the volume of the bulk sample using the following equation:

eg. $V = A \times ht$

Volume (V) = 14,240 cm^3 (or 14.24 L)

Bulk area (A) = 2500 cm^2

$ht = \frac{V}{A} = \frac{14240\ cm^3}{2500\ cm^2} = 5.696\ cm = 56.96\ mm$

$\therefore$ 14,240 ml of precip = 56.96 mm of depth

The plastic bulk bucket used in the winter months was interchanged with a clean one after scraping down the funnel to ensure that the whole event was sampled. The plastic lid and piece of plastic sheeting used to cover the clean bulk bucket while in transit to the site was placed on the full bulk bucket for transportation back to the lab. The scraper was made of a flexible plastic material so as not to etch the teflon-coated funnel. The scraper was washed with Extran 300 and multiple rinsed in distilled water at the lab and kept in a clean plastic bag while not in use, in order that non-event contaminants were not introduced into the sample.

During the period of summer operation, a plastic container was connected to the small-mouthed funnel with tygon tubing (type T-28). The tygon tubing was looped once between the funnel and the container to reduce evaporative loss. This also provided a trap for coarse particulates that bypass the roll of fine mesh nitex screening located in the neck of the funnel. After looping the tygon tubing, the free end was inserted through a pre-drilled hole in the plastic cap a distance of 7.62 cm. At this point, the fine mesh nitex screening was rolled into a cylinder and inserted into the neck of the funnel until it extended into the tygon tubing a distance of 1 cm. The nitex screening was thus situated approximately 1 cm above the throat of the funnel. Disposable plastic gloves were worn during all of the above operations.

After an event of sufficient volume occurred (10 mm), the plastic container was removed and the pre-drilled hole in the cap was plugged with a plastic insert. At this time the tygon tubing and nitex mesh screening was removed and discarded. The funnel was checked for contaminants (leaves, insects or fecal deposition) and if cleaning was required, it was done with dstilled water and a nonabrasive cloth (eg. Kim Wipes). Dry airborne particulates were considered part of the event period and were not removed.

All bulk precipitation samples were filtered through 76 µm mesh before filling the appropriate sample containers. The total volume of the sample was measured and recorded. The measuring 4-L graduate cylinder and the filter was rinsed thoroughly with distilled water between stations to avoid cross contamination. Each precipitation sampling container was rinsed with distilled water four or more times and covered with the appropriate lids before re-use in the field.

ii) Data Logger and Associated Equipment Description:

Section A-4 (Figure 2) indicates the enclosure from which the data collection and transmission occurs. Located inside the

shed was a CR21 micrologger, connected to a Panasonic RQ 356 mini cassette recorder. To collect year-round data, these instruments were heated by a Cata Dyne Mini Heater (non-flame), using propane fuel. The Cata Dyne heater was factory calibrated to produce 600 B.T.U. per hour and will continue to produce 20 B.T.U. per hour once the thermostat is satisfied. The starting and safety instructions are located on the frame of the heater. The thermostat should be set at 5 on the dial to maintain the data transmission equipment at a minimum 15°C operating temperature. A winter setting of 7 was maintained with these temperature settings, two one-hundred lb. propane cylinders were adequate fuel for one year.

Equipment necessary for the operation of the CR21 during summer period (May 1-October 31) included:

1) Dessicant packets changed when necessary. If condensation started to collect inside the data transmission shed, the heater was started and set the thermostat at setting #3.

Winter operation (November 1-April 30) required the following equipment and procedures:

1) The battery-packs were changed at the seasonal change-over period.
2) The heater was started and a 15°C temperature reading was maintained.
3) The snow was removed from the data collection shed roof if it reached a depth greater than 30 cm.

The instructions to calibrate and programme the CR21 Data Logger and associated equipment is given in Campbell Scientific, 1983 (reference available on site).

The CR21 is capable of sampling data at one minute intervals or at time intervals as specified by the user. This data is then processed and stored according to the output program specifications. At the end of each output interval, processed data is stored in final memory of the CR21 in 412 data point groups. Upon reaching this number, the CR21 transmits the data via the I/O port to the cassette.

For the first six months, the cassettes were changed on a monthly cycle. This allowed a check of the accuracy of the equipment against the existing network and Environment Canada records. Cassettes will now be left in operation for a period of 6 months.

Upon arrival at the site, the following procedures were performed, and the results recorded.

1) Check the battery voltage.
2) Check the accumulated precipitation for the week using the command as specified earlier and compare this to the Belfort weekly precipitation chart. At this time, if more than 10 mm of precipitation has fallen, then change the 2500 cm^2 bulk precipitation collector.
3) Check the current temperature and relative humidity.
4) Check the time and correct if necessary, eg., from standard time to daylight saving time. Record the time of the visit on the appropriate forms and note any discrepancies between the real time and the digital display on the CR21.
5) Check the tape footage indicator on the RQ 356 and check against the previous week's footage. An advancement of approximately 20.32 cm should occur. If no advancement has taken place, check all connections and follow the procedures as specified in the CR21 manual.
6) The final step at the end of each visit is to press the *0 key. This will result in the display showing the logging date (eg. 99) and the actual time on the 24-hour clock (eg. 10:45). If you fail to code *0, the CR21 will not collect or tabulate any data.

iii) Belfort Gauge Equipment Description:

Section A2 (Figure 2) shows a Belfort rainfall depth transmitter collector with a 20.32 cm diameter orifice. It is set at a standard height of 2.54 m above ground level at the three new sites. The collection tube mouth should be maintained at a height 12.70 mm above the altershield.

Equipment necessary for the Belfort gauge (summer frost-free period, May 1-October 31) includes:

1) Collection tube fitted with a funnel, which is not connected to the collection bucket.
2) Galvanized pail with a 13.62 L capacity.
3) Added to the bucket will be 500 ml of S.A.E. 30 Oil (used to prevent evaporation).

For winter operation (November 1-April 30) the following equipment alterations are required:

1) Funnel-mouth of collection tube is removed.
2) Added to the bucket for winter operation are:

    2,000 ml Ethylene Glycol
    800 ml Methanol
    500 ml S.A.E. 30 Oil

The instructions to install and calibrate the Belfort Gauge is given in Belfort Inst., 1973, (reference available on site).

The Belfort gauge is connected to the CR21 micrologger; used to record voltages translating into water depth equivalents. The Belfort chart drive is battery-operated, utilizing 2 (two) 1.5 V "D" cell batteries. This chart has a rotation of 168 hours (7 days) and a full scale before needle deflection of 150 mm of precipitation. The chart is set to time by lowering the pen and rotating the chart cylinder to the proper day and time.

After the setup and calibration of the rainfall transmitter has been completed, basic routine procedures are required to insure continuous collection of data. On a weekly basis, the chart drive assembly must be checked. This entails changing the chart, checking the pen for ink, and making sure that the clock mechanism is rotating freely (batteries are to be changed at the seasonal change-over period). The collector tube should be removed and any foreign objects cleaned from the funnel mouth. With the collection tube removed, an inspection of the catch bucket should be carried out. If the bucket is approaching peak capacity of 250 mm combined charge and precipitation, it should be removed and the contents emptied into a 22.73 L plastic container located at each site. The catch bucket should be

recharged according to the season and replaced on the weighing platform. When replacing the catch bucket on the weighing mechanism, do not subject the instrument to sudden shock.

iv) Thermistor and Relative Humidity Probe Equipment Description:

Section A3 (Figure 2) shows a model 201 Thermistor and Relative Humdiity Probe set at a standard height of 2.54 m above ground level at the three new sites. This instrument is a self-contained unit and comes from the factory already calibrated, and relatively few problems should be encountered. However, a number of guidelines must be followed to ensure accurate and continuous data.

1) The surface of the sensor should not be touched or contaminated in any way.
2) The sensor should be held only by its terminals or its two edges.
3) The sensor should not be exposed to organic solvents or to liquids with high ion content.
4) Contamination by exposure to soil must be avoided.
5) The sensor should not be subjected to liquid immersion or water contamination.
6) The sensors are particularly susceptible to contamination by sulphur gases, therefore, smoking near the sensors is prohibited.
7) If the sensor is to be connected by soldering its terminals, proper heat sink techniques must be employed. The upper temperature limit is approximately 200°F.
8) For removal of dust or dirt, use a gentle clean (oil-free) air blast, or brush with a camel hair brush.
9) The sensor's mounting plate should be painted white, thus minimizing the albedo effect on the sensor.

The thermistor and relative humidity probe are connected to the programming CR21 micrologger. Upon arrival at the site, the current temperature and the previous week's maximum and minimum temperatures are recorded from the max/min thermometer, and the values checked against the CR21 readings. A discrepancy of

more than 20 units should be reported. At the same time the relative humidity should be recorded from a sling psychrometer and the values checked against the CR21 micrologger.

4.3 Ministry of the Environment - Air Resources Branch (ARB)

The Dorset station is currently the only ARB site with information stored on the data base. In addition to the standard climate instrumentation of Stevenson Screen with max/min thermometer, SRG and snow ruler, ARB operates the following other meteorological monitoring equipment:

- MSC pattern tipping bucket rain gauge system
- Sangamo monthly precipitation sampler - a double bucket collector that collects both the wet and dry deposition into polyethylene bags operated by a moisture sensing grid.
- Aerochemetric daily event precipitation sample, same collector as Sangamo
- Sequential Air Sampler, weekly low volume measurement of daily ozone
- Fischer Porter Recording Precipitation Gauge
- Nutech pump filter system to collect monthly samples of particulates and sulphur dioxide (set up at 20 Sangamo sites), AC/DC gas sampler for remote sample collection using wet chemical collectors and gas chromatography cartridges.
- Dichotomous Sampler which samples and size fractionates suspended particles into two size fractions (2.5 - 15μ, coarse, non-respirable and <2.5 μ fine, respirable), collected onto two 37 mm Teflon membrane filters. Chemical analysis by x-ray fluorescence or gravimetric analysis by microbalance or beta radiation attenuation.

4.4 Other Source Agencies

There are a number of other government agencies and university groups identified in Table 1 that in the future will contribute data to the DRC meteorological data base. Instrumentation, or gauge code information for these groups is given in Tables 2 and 3.

5. References

Atmospheric Environmental Service. Jan. 1977. Manual of Climatological Observations. U.D.C. 551.501.1, Downsview, Ontario.

Atmospheric Environment Service. 1985.04.10. Documentation for the Digital Archive of Canadian Climatological Data (Surface) Identified by Element. Downsview, Ontario.

Belfort Instrument Company. 1973. Instruction Book for Rainfall Transmitter, Book No. 9670, Cat. No. 5915 Series. Balt., Maryland.

Campbell Scientific Inc. 1983. CR21 Micrologger Operator's Manual. Logan, Utah.

Martin Goebel Assoc. 1983. Dorset Area Meteorological Data. Proposal and Guide for a Data Base. Prepared for the Ministry of the Environment.

Appendix 6.1. Source Agency Information

Agency Code	Organization	Contact Personnel	
AES	Environment Canada - Canadian Climate Centre, Atmos. Env. Serv.	G. Bristow	416-667-4953
		M. Webb	416-667-4953
		S. Hardaker	416-973-5822
		N. McPhail	416-667-4656
AES	National Water Research Institute Canada Centre for Inland Waters (CCIW)	E. Smith	416-336-4920
		J. Bull	416-336-4920
		J. McAvella	416-336-3920
ARB	Ontario Ministry of the Environment Air Resources Branch	J. Kurtz	416-965-1193
		W. Chan	416-965-1634
		M. Lusis	416-965-1634
DRC	Ontario Ministry of the Environment Limnology Unit Dorset Research Centre	B. Locke	705-766-2412
		E. de Grosbois	705-766-2412
MNR	Ministry of Natural Resources		
	Whitney	M. Paquette	613-637-2780
	Huntsville	F. Inwood	705-789-9611
		J. Tye	613-637-2780
HYD	Ontario Hydro	B. Handy	416-965-1634
		D. Knebel	416-231-4111 (ext. 7065)

Appendix 6.2. Hewlett-Packard Regression Format

Record 1: T$, (title string length 80)
No, (number of observations in file)
Nv, (number of variables in file: this is always 3 for METEOR files)
Un$(50), (string array of variable names each length 10)
Ns, (no of subfiles)
Sn$(20), (string array of subfile names each length 10)
Sc (20), (array of subfile starting observation numbers)

Record 2: D(Nv,No) (array for data, free field format)
(can be full precision or short precision)

Record n: EOF

Missing values are indicated as -9999999.99999 in full precision and -1E7 in short precision.

Appendix 6.3. 'METEOR'

'METEOR' is a data base product developed to assist in estimating and organizing meteorological data from the existing data base. It accesses all of the meta-data pertaining to the data base and therefore provides a useful summary of the available information and its sources. 'METEOR' enables the retrieval of original data for existing meteorologic sites and can be used to estimate missing data items based on a strategy of equal-weighted or distance-weighted nearest neighbours. The estimation strategy can be user-defined in terms of the maximum number of near neighbours considered as well as the power term for distance weighting these neighbours. Based on a weighting factor, $w = 1/(\text{distance})^p$, if $p = 0$, then equal weights ($w = 1$) are applied, if $p = 1$, then w = euclidian distance weighting, and so on (with the restriction: $0 \leq p < 100$. The resultant estimate is calculated as the sum of weighted values divided by the sum of weights for n near neighbours:

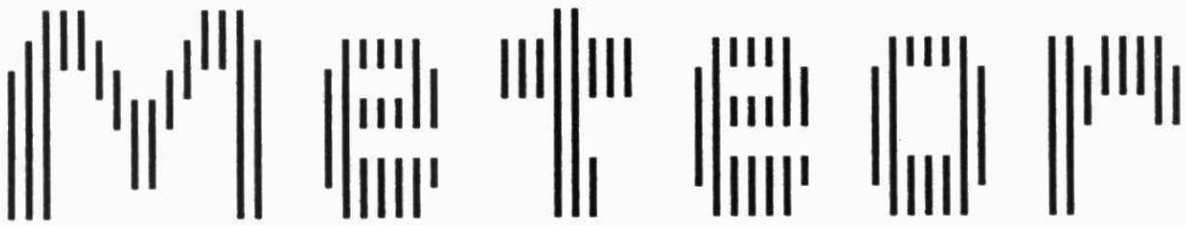
$$Ve = \Sigma\ (Wn \cdot Vn)/\Sigma\ Wn$$

where n is the number of near neighbours

and Wn, Vn are the weights, and values respectively, at each near neighbour, n.

'METEOR' will produce a completely estimated vector of meteorologic data if a non-existing site location is specified (ie. all data for that set of UTM co-ordinates is declared missing). This option can also calculate a regional mean if equal-weighting is used. If an existing site location is specified, 'METEOR' will retrieve the original data for the site, and will only estimate data for those items that are missing, using the estimation strategy specified. Final output from 'METEOR' is in an identical format to the meteorological data sets: Date, Meteorologic Variable, and Quality Control Code. The quality control codes indicate whether a data item is estimated, on how many neighbours it was estimated, and the weighting factor used. For example, a "0" indicates a real, non-missing data item for the site indicated, and "13" indicates a missing value. A QC code for estimated values is a number in the eighties, e.g. "83.1", which in this case is an estimate based on 3 near neighbours where the weighting factor used is $w = {}^1/(\text{distance})^1$, that is $p = 1$.

The 'METEOR' program can be accessed on HP 9845B floppy disk #231. A sample estimation problem is shown below. The example is for Harp Lake (760101 to 840630) total daily precipitation using a distance weighted mean of the nearest one neighbour. The user input required is marked by arrows in the left margin. Additional information on running this program is available from Ed deGrosbois or Barb Locke.



```
THIS PROGRAM IS THE LATEST VERSION OF METEOR. IT WAS FORMERLY
CALLED 'M1'. THE OLD METEOR VERSION IS RE-NAMED TO 'M-OLD' AND
SUPPORT FILES RE-NAMED TO 'V-OLD' AND 'U-OLD' RESPECTIVELY. IT
IS INTACT AND CAN BE RUN IF PROBLEMS DEVELOP WITH THIS VERSION.
THE SITE EDITOR PROGRAM IS NOW CALLED 'M-SITE' AND THE VARIABLE
EDITOR IS CALLED 'M-VARS'.  BOTH ARE ON THIS DISK.  THEY CREATE
AND UPDATE THE METEOR SOURCE CODE FILES 'MSITES' AND 'MVARS'.
ENTER AN MSUS FOR DATA DRIVE:
:F

                METeorological Estimator and ORganizor

METEOR functions:    1. Read MET data on mag tape or data loggers
                     2. Select meteorological data by variable
                     3. Select meteorological data by MET sites
ENTER DESIRED OPTION:
→2
```

```
Code       Element VV        Code       Element VV        Code       Element T

01 DLY AIR TEMP.(deg C)      37 DLY WIND MILEAGE (km)     A  actual observations
02 DLY WATER TEMP.(deg C)    40 DLY MEAN HRLY SO2         M  mean value for period
05 DLY DEWPT TEMP.(deg C)    45 DLY MEAN HRLY NOX         T  total accumulated
10 DLY PREC. (mm H2O)        50 HLY AIR TEMP. (deg C)     U  maximum for period
11 DLY PREC. rain(mm H2O)    55 HLY DEWPT TEMP.(deg C)    L  minimum for period
12 DLY PREC. snow(mm H2O)    60 HLY PREC. (mm H2O)        S  scalar average
13 DLY PREC. snow(depth)     61 HLY PREC. rain(mm H2O)    V  vector average
15 DLY BRIGHT SUN (h)        62 HLY PREC. snow(mm H2O)
16 DLY SOLAR RAD'N (lys)     65 HLY BRIGHT SUN (h)
17 DLY P.A. RAD'N (lys)      66 HLY SOLAR RAD'N (lys)
18 DLY MAX. SUN (hr)         67 HLY P.A. RAD'N (lys)
20 DLY REL. HUMIDITY (%)     70 HLY REL. HUMIDITY (%)
21 REL.HUMIDITY 13h00 (%)    75 HLY VAP. PRESSURE (mb)
25 DLY VAP. PRESSURE (mb)    81 HLY PAN EVAP. (mm)
31 DLY PAN EVAP. (mm)
32 DLY LAKE EVAP. (mm)
35 DLY WIND SPEED (km/h)
36 DLY WIND DIR. (deg)
ENTER VARIABLE CODE VVT:
→10T
 PLEASE
 INSERT D##273 IN :F (and hit 'CONT')
```

```
AE1 ALGONQUIN AIR/MEW L.   FR1 FROST CENTRE (L.M.)     OP1 OPEONGO Lk HARKNESS
AE2 ALGONQUIN EAST AFAU    GF1 GULLFEATHER (raft)      OX1 OXTONGUE R. MNR Eng
AE3 ALGONQUIN EAST GATE    GR1 GRAVENHURST             PC1 PLASTIC Lk raft PCPR
AE4 ALGONQUIN EAST bmass   HA1 HALIBURTON A            PC2 PLASTIC Lk gravelpit
AW1 ALGONQUIN WEST GATE    HP1 HARP Lake (Raft)        PC3 PLASTIC LAKE North
BE1 BEATRICE 1             HP2 HARP Lk 3A watershed    PC4 PLASTIC LAKE Terres.
BE2 BEATRICE 2             HP3 HARP Lk 4 watershed     RC1 RED CHALK LAKE raft
BR1 BRACEBRIDGE 1          HP4 HARP Lk #4 terrest.     SM1 SMOKE LAKE AIR BASE
BR2 BRACEBRIDGE 2 (MB1)    HP5 HARP Lk #7->#3A weir    ST1 STONECLIFFE
CA1 CARNARVON Reid home    HU1 HUNTSVILLE WPCT         TR1 TRAVERSE Lk ALG.PK
CL1 CLEAR L. island stn    HY1 HENEY Lk west field     VA1 VANKOUGHNET
CN1 CROSSON L. (raft)      HY2 HENEY Lk east field     VA2 VANKOUGHNET Clear Lk
D01 DORSET metsite:VARTO   LI1 LINDSAY-SSFC            WG1 W. GUILFORD
D02 DORSET PT1 Paint Lk.   MB1 MILFORD BAY now BR2     WH1 WHITNEY
D03 DORSET PT1 MicroSite   MI1 MINDEN Jan 1 1956 ->    WL1 WILLIAMSPORT
D04 DORSET PT1 Met site    MU1 MUSKOKA AIRPORT FSS
DW1 DWIGHT                 NB1 NORTH BAY AIRPORT
EA1 EAGLE L.(hydro line)   NI1 NITHGROVE
 A 2-digit mnemonic will generate an estimate for each case.
 A 3-digit mnemonic generates estimates only for missing cases.
ENTER A VALID SITE CODE FROM LIST ABOVE (e.g. SS or SSS):
→HP1
```

```
HP1 EXISTING SITES WITH THIS MNEMONIC:

HP1    HARP Lake (Raft)        Source: DRC  Mag tapes:
       MET GAUGES:GAUGE1 GAUGE2 GAUGE7
       UTM easting 646050 northing 5026700    NO DATA AVAILABLE YET


NOTE:Data for HP1 will be estimated only if missing. To obtain
     a completely estimated vector: enter 'SS' only (2 DIGITS)
OK TO CONTINUE? (YES/NO)  (a NO will return you to the SITES menu):
→ "YES"


MET DATA FROM 730130 TO 841031 CAN BE ESTIMATED FROM NEIGHBOURING MET SITES


NOTE: If you are generating MET files for the EVAPR8 program it is
      advisable to start one month before your evaporation period
      and end one month after.
ENTER A STARTING DATE yymmdd FOR THIS FILE:
→760101
ENTER A END DATE yymmdd FOR THIS FILE:
→840630
 setting up the date vector: one moment please...


TREATMENT OF MISSING VALUES IN THIS FILE
   All non-missing values will be taken from data for HP1. Only
   missing values will be estimated according to selected options.


METEOR WILL CALCULATE AN ARITHMETIC MEAN OF UP TO 5 NEAREST NEIGHBOURS.
EACH NEIGHBOUR CAN BE DISTANCE WEIGHTED (OR NOT) IN ITS CONTRIBUTION TO THE MEAN
ENTER THE NO. OF NEAR NEIGHBOURS TO BE CONSIDERED FOR THIS ESTIMATE:
→1

WEIGHTING FACTOR: P
   THE WEIGHTING FACTOR WILL BE CALCULATED AS THE RECIPROCAL OF
   THE DISTANCE BETWEEN THE TARGET POINT AND ITS NEAR NEIGHBOURS.
   ie. W=1/(Distance)^P
   THE ESTIMATE IS CALCULATED AS THE SUM OF THE VALUES AT THE NEAR
   NEIGHBOURS TIMES THEIR RESPECTIVE WEIGHTS, ALL DIVIDED BY THE
   SUM OF THE WEIGHTS.  HENCE: P=0 WILL PRODUCE AN ARITHMETIC MEAN,
   P=1 PRODUCES DISTANCE WEIGHTED MEANS, AND P=2 PRODUCES DISTANCE
   SQUARED MEANS (EACH MEAN IS BASED ON N NEAR NEIGHBOURS).
ENTER POWER TERM P FOR WEIGHTING FACTOR (must be non-negative and less than 10
→1

        NAME          DISTANCE(m)    EASTING    NORTHING    START DATE    END DATE
Target:HARP Lake (R          0.0     646050     5026700        760101      840630
Nearest
 Sites:HUNTSVILLE W       7884.3     640500     5021100        760101      999999
       DWIGHT            11582.9     656400     5021500        730130      999999
       DORSET metsi      23622.6     662400     5009650        770901      999999
METEOR is now getting source data for: HUNTSVILLE WPCT
METEOR is now getting source data for: DWIGHT
METEOR is now getting source data for: DORSET metsite:VARTO
METEOR is now estimating data for: HP110T
DO YOU WISH TO STORE THIS DATA
→ "YES"
IS DATA STORAGE DISC PLACED IN DRIVE? (YES/NO):
→ "YES"
EDIT A TITLE FOR THE NEW DATA SET (MAX 80 CHARS.):
→10T ESTIMATES FOR HP
EDIT THE NAME OF THIS DATA SET (MAX 6 CHARS.):
→HPe10T
ENSURE THAT THE DATA DISK IS IN DRIVE :F (and hit 'CONT')
HPe10T HAS BEEN STORED ON D##320
RUN METEOR AGAIN?
```

Appendix 6.4. 'EVAPR8'

'EVAPR8' is a program designed to estimate periodic evaporation (mm) over a lake surface area. Required meteorological data inputs are measured or estimated daily solar radiation (langleys), mean daily air temperature (°C), daily total bright sunshine (hours), and mean daily relative humidity (%). These data can be obtained from the 'METEOR' system. The 'EVAPR8' program calculates an estimate of maximum possible sunshine hours per day (based on date), the saturation vapour pressure gradient of the air (based on air temperature) and the saturation vapour pressure of the water (based on surface water temperature).

The calculation of evaporation is based on an energy budget approach similar to that used by Barry and Robertson (1975). It requires information on lake heat content and surface temperature of the lake in addition to the meteorologic variables. The latent heat of evaporation is calculated as:

$$LE = \frac{Zr - Al}{1 + B}$$

where Le is the latent heat of evaporation ($cal^{c}m^{-2}$)

Zr is the net radiation ($cal \cdot cm^{-2}$)

Sl is the change in areal heat content of the lake ($cal^{c}m^{-2}$)

and B is Bowen's ratio

where $B = C \cdot \frac{Tw-Ta}{Ew-Ea}$

where C is the Bowen ratio constant (=.474°C per Hg)

Tw is the water surface temperature

Ta is the air temperature

Ew is the saturation vapour pressure of the water

Ea is the saturation vapour pressure of the air

Hence, the depth of water evaporated (in cm) is:

$E = Le/590 \ cal \cdot g^{-1}$

(590 $cal \cdot g^{-1}$ is the latent heat of vapourization of water)

Ref: P.J. Barry and E. Robertson: "The Energy Budget of Perch Lake", in Hydrological Studies on a Small Basin on the Canadian Shield, publ.

A sample estimation of evaporation for Harp Lake, 1980-1984 is shown below with user input marked by arrows in the left margin. The file 'HP 8084' was previously stored on the 9845 system with dates and necessary meteorological information.

EVAPOR-8

```
EVAPOR NEEDS COMMON BLOCK METEOROLOGICAL DATA FROM RA SYSTEM WITH:
        DATE (YYmmDD.HHmmSS)
        RELATIVE HUMIDITY
        AIR TEMPERATURE
        SHORT WAVE RADIATION
        HOURS OF BRIGHT SUN

A HEAT BUDGET FILE (RA FORMAT) WILL ALSO BE REQUIRED
'CONT' TO CONTINUE OR SPF KEY TO RETURN TO REGRESSION ANALYSIS




PRINTER OPTIONS:  1. SCREEN
                  2. INTERNAL PRINTER
                  3. HPIB PRINTER
SELECT OPTION FOR PRINTER:
→3




METEOROLOGY FILE:PLASTIC LAKE EVAP CALC FILE 790601-840531     ] ...previously loaded on
VARIABLES:                                                     ] EVAPR-8 program disk
 1 RAD (lv)
DO YOU WISH TO LOAD A DIFFERENT FILE FOR METEOROLOGICAL DATA? (Y/N):
→Y
ENTER A FILE SPECIFIER FOR THE MET DATA:
→HP8084:F

CAUTION: If, after recalling part of a file, it is re-stored into the same file,
only the recalled part will be kept.

                  OPTIONS:

                  Specify variables----------------------------1

                  Specify observations-------------------------2

                  Specify variables and observations-----------3
Option number = ?
→1




 1 SOL RAD      2 DATE         3 01Mest       4 15Test       5 20Mest

RULES FOR INPUT OF VARIABLE NUMBERS:

        DASHES indicate a range of consecutive variable numbers.
               from LOW end to (dash) HIGH end: e.g. 4-9=4,5,6,7,8,9
        COMMAS separate range items and individual variable items.
INPUT VARIABLE NUMBERS (RANGES):
?
→1-5
```

```
 THE VARIABLES YOU HAVE SELECTED ARE:

  SOL RAD      DATE         01Mest       15Test       20Mest
 Is the above information correct
→YES



 Recall beginning with Observation # ?
→1
 Recall beginning with Observation # 1
 Ending with Observation # ?
→No
 Ending with Observation # 1461
 IS ABOVE INFORMATION CORRECT?
→YES



 METEOROLOGY FILE:HARP LAKE EVAPORATION CALC FILE 800601-840531
 VARIABLES:
  1 SOL RAD    2 DATE       3 01Mest     4 15Test     5 20Mest
 DO YOU WISH TO LOAD A DIFFERENT FILE FOR METEOROLOGICAL DATA? (Y/N):
→N

  IDENTIFY THE VARIABLES IN THE MET FILE:

 ENTER THE VARIABLE NO. FOR THE DATE:
→2
 DATE:                2 DATE
 ENTER THE VARIABLE NO. FOR THE AIR TEMPERATURE:
→3
 AIR TEMP:            3 01Mest
 ENTER THE VARIABLE NO. FOR THE RELATIVE HUMIDITY:
→5
 REL. HUMIDITY:       5 20Mest
 ENTER VARIABLE NO. FOR SHORT WAVE RAD'N: (0 = enter NET Rs for each heat budget)
→1
 SOLAR RAD'N          1 SOL RAD
 ENTER THE VARIABLE NO. FOR THE HOURS OF BRIGHT SUN:
→4
 BRIGHT SUN:          4 15Test
    ONE MOMENT PLEASE
```

```
TIME TO LOAD THE HEAT BUDGET FILE:

HEAT BUDGET FILE MUST BE PA FORMAT
most heat budget files can be found on D##018
ENTER A FILE SPECIFIER FOR THE HEAT BUDGET FILE:
→ CAT*.F*
NAME  PRO TYPE REC/FILE  BYTES/REC   ADDRESS
FS          05

D##018    DATA       1        256       2/00
HEAT      DATA      44        256      35/02
HHP       DATA       5       1280      36/16
HHCn      DATA       5       1280      37/11
HJT       DATA       2       1280      14/11
HBC       DATA       4       1280      18/26
HBH       DATA       3       1280      19/16
HBK       DATA       3       1280      19/26
HBW       DATA       3       1280      20/06
HCB       DATA       4       1280      20/16
HCL       DATA       2       1280      21/06
HCN       DATA       3       1280      21/16
HCR       DATA       2       1280      22/01
HDE       DATA       4       1280      22/11
HDQ       DATA       2       1280      23/01
HGF       DATA       3       1280      23/11
HGN       DATA       3       1280      23/21
HHH       DATA       3       1280      24/01
HHY       DATA       3       1280      25/01
HLA       DATA       3       1280      25/16
HLC       DATA       3       1280      25/26
HLI       DATA       3       1280      26/06
HME       DATA       3       1280      26/16
HPC       DATA       3       1280      26/26
HRCE      DATA       3       1280      27/11
HSE       DATA       2       1280      28/16
HSn       DATA       3       1280      28/26
HTF       DATA       3       1280      29/06
HWD       DATA       3       1280      29/16
HWR       DATA       3       1280      29/26
JOIN      DATA       1        256      30/06
HAX       DATA       3       1280      30/12
HBQ       DATA       3       1280      30/22
HBP       DATA       3       1280      31/02
HBY       DATA       3       1280      31/12
HCW       DATA       3       1280      31/22
HFN       DATA       3       1280      32/02
HHE       DATA       3       1280      32/12
HKL       DATA       3       1280      32/22
HLD       DATA       3       1280      33/02
HLM       DATA       3       1280      33/12
HmO       DATA       3       1280      33/22
HNI       DATA       3       1280      34/02
HRP       DATA       3       1280      34/12
HSH       DATA       3       1280      34/22

→ HHF F

CAUTION: If, after recalling part of a file, it is re-stored into the same file,
only the recalled part will be kept.

                    OPTIONS:

                    Specify variables----------------------------1

                    Specify observations-------------------------2

                    Specify variables and observations-----------3
Option number = ?
→
```

```
  1 DATE        2 Heat (cal)   3 Surface T    4 CAL A=71.4
RULES FOR INPUT OF VARIABLE NUMBERS:

        DASHES indicate a range of consecutive variable numbers.
              from LOW end to (dash) HIGH end: e.g. 4-7=4,5,6,7,8,9
        COMMAS separate range items and individual variable items.
INPUT VARIABLE NUMBERS (RANGES):
?
→ 1-4



THE VARIABLES YOU HAVE SELECTED ARE:

DATE        Heat (cal)   Surface T    CAL A=71.4
Is the above information correct
→ YES



Recall beginning with Observation # ?
→ 1
Recall beginning with Observation # 1
Ending with Observation # ?
→ NO
Ending with Observation # 241
IS ABOVE INFORMATION CORRECT?
→ YES



HEAT BUDGET FILE:HP Heat content  calculation output. VAR 4 HEAT CONTENT USING A
REA 1985/71.4
VARIABLES.
 1 DATE       2 Heat (cal) 3 Surface T  4 CAL A=71.4
DO YOU WISH TO LOAD A DIFFERENT HEAT BUDGET FILE? (Y/N):
→ N

 IDENTIFY THE VARIABLES IN THE HEAT BUDGET FILE:

ENTER THE VARIABLE NO. FOR DATE:
→ 1
DATE:              DATE
IS THIS A DAY IN CENTURY DATE
→ YES
dates are day-in-century
ENTER THE VARIABLE NO. FOR SURFACE WATER TEMPERATURE:
→ 3
WATER TEMP:        Surface T
ENTER THE VARIABLE NO. FOR LAKE HEAT CONTENT:
→ 2
HEAT CONTENT:      Heat (cal)
EDIT TITLE OF OUTPUT PAGE
→ HAPP LAKE EVAPORATION CALC FILE 800601-840531
ENTER THE SURFACE AREA OF THE LAKE (in M^2):
→ 4.69E5
```

```
BOWEN RATIO CALCULATION:

  BOWEN found the limiting values of 'c' to range from .58 to .65
  with an average value under normal atmospheric conditions of .61

  BARRY & ROBERTSON use a value of .474 (no reference given)
ENTER THE 'C' CONSTANT FOR THE BOWEN RATIO CALCULATION:
--> .61

ENTER THE SPRINGTIME 'ice-off' DATE:
--> 820501
ENTER THE FALL 'ice-on' DATE:
--> 821201
# OF DAYS IS 4  FROM  820501  TO  820504
```

HARP LAKE EVAPORATION CALC FILE 800601-840531
EVAPORATION CALCULATION FOR HEAT BUDGET PERIOD T1: 820501 TO T2: 820504
HP Heat content calculation output. VAR 4 HEAT CONTENT USING AREA 1985/71.4

DATE yymmdd mday	DAY Nd	AIR TEMP deg C Ta	RELATIVE HUMIDITY % Rh	TOT SOLAR RADIATION langleys Rs	HRS BRITE SUNSHINE hrs. So	MAX POSS HRS SUN hrs. Sm
820501	1	9.99	31.00	503	6.94	14.21
820502	2	8.45	52.00	421	9.62	14.27
820503	3	8.82	43.00	545	11.77	14.29
820504	4	10.24	41.00	648	13.05	14.35
TOTAL:	4			1542	31.38	42.84
MEAN:		9.37	32.75			

Tw1: Water temp at T1:	4.18 deg C	Tw2: Water temp at T2:	7.46 deg C
Tw: Mean water temp:	5.82 deg C	Ta: mean air temp:	6.85 deg C
Dt: Water-Air gradient:	-1.03	D: D parameter:	2.00

Ew1: Water Sat vap press T1:	6.1831	mm Hg	
Ew2: Water Sat vap press T2:	7.7714	mm Hg	
Ew: Mean Water Sat vap pressure:	6.9773	mm Hg	
Ea: Mean Air Sat vap pressure:	2.4292	mm Hg	
Ead: mean vapor pressure of air:	2.4292	mm Hg =	3.2379 (mb)
De: Vapor pressure gradient:	4.5480	mm Hg	
Rh: mean rel. humidity as ratio:	0.3275		
C: Bowen Ratio Constant:	0.6100		
B: BOWEN RATIO:	-.1377		

S11: Areal Heat content T1:	5301.1659	cal/cm2
S12: Areal Heat content T2:	6765.6801	cal/cm2
S1: Areal heat content gradient t2-t1:	1464.5142	cal/cm2
Rs: Solar rad'n corrected by albedo:	1418.4580	Langlys
Rl: Long wave radiation loss:	434.3315	Langlys
Rr: NET radiation:	984.1245	Langlys
Le: Latent heat of evaporation:	-557.1253	cal/cm2
H: Sensible heat loss to atmosphere:	76.7356	cal/cm2
E: Depth of water evaporated:	-9.4428	mm

Evaporation calculations continue to 821201 with printed output.
When the calculations are done...

```
DO YOU WISH TO COMPUTE EVAPORATION FOR ANOTHER HEAT BUDGET PERIOD? (Y/N):
--> N
```

TL
798
.M4
M48
1986